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Lean and Agile Manufacturing in Natural Food Production:
The Key to Saving America's Health and Environment

by

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A Thesis

Presented to the Graduate and Research Committee

of Lehigh University

in Candidacy for the Degree of

Master of Science

in

Manufacturing Systems Engineering

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Emily Kristina Gumbulevich

This thesis is accepted and approved in partial fulfillment of the requirements for the Master of Science.

Date

Professor Keith Gardiner, Department Chair

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ABSTRACT

Food production in the United States impacts the economy, environment, national security, and public health. Reports that the current system of production is highly vulnerable to terrorist attacks and disease have gone unaddressed for nearly 20 years as issues such as recalls of meat are unnoticed for entire yearlong production cycles and machinery falling into disrepair leaving metal shards behind in processed foods are more prevalent. The rising prevalence of obesity, heart disease, and diabetes have been linked to diet, but the American diet has not changed – largely due to the prevalence of high fructose corn syrup in quickly accessible, cheap processed foods. The American food manufacturing system is not sustainable by the environment and must be changed if current levels of natural resource depletion and population growth are to be sustained.

The food manufacturing system in America resembles old mass production lines of 20th century American manufacturing – the very systems that caused several American operations to declare bankruptcy and close doors. The government subsidies and lobbies have kept big agriculture in America afloat, but changing consumer demands, rising costs, and environmental implications require a change. The change needed is the same manufacturing change that the companies that survived the demise of most 20th century American manufacturers adopted – that of Lean and Agile Manufacturing.

INTRODUCTION

Food manufacturing in the United States has reached a pivotal point in its history in which manufacturers need to begin making the choice to change practices ahead of the regulation curve, or will be forced to quickly adopt new standards at a higher cost in coming years. Apart from the negative environmental implications of the currently centralized food manufacturing process, the health implications for the American population are severe. In a 2009 article, critically acclaimed academic and journalist Michael Pollan points out that since “three-quarters of health care spending [went] to treat ‘preventable chronic diseases’...many, if not most of them [linked to diet],”¹ the debate about the rising costs of health care are inextricably tied to the Western diet and contributing food manufacturing practices.

The United States Centers for Disease Control statistics referenced by Pollan have only become graver since his article –

- Obesity is a serious health concern. During 2009-2010, more than one-third of adults, or about 78 million people, were obese (defined as body mass index [BMI] ≥ 30 kg/m²). Nearly one of five youths aged 2-19 years was obese (BMI $\geq 95^{\text{th}}$ percentile).
- In 2011, more than one-third (36%) of adolescents said they ate fruit less than once a day, and 38% said they ate vegetables less than once a day. In addition 38% of adults said they ate fruit less than once a day, and 23% said they ate vegetables less than once a day.
- Eighty-four percent of all health care spending in 2006 was for the 50% of the population who have one or more chronic medical conditions.
- Medical costs linked to obesity were estimated to be \$147 billion in 2008.²

¹ Michael Pollan, “Big Food vs. Big Insurance,” *The New York Times*, September 10, 2009, accessed April 15, 2015, http://www.nytimes.com/2009/09/10/opinion/10pollan.html?pagewanted=all&_r=0.

² “Chronic Disease Prevention and Health Promotion,” Centers for Disease Control, <http://www.cdc.gov/chronicdisease/overview/index.htm>, accessed April 18, 2015.

These staggering negative trends show a clear linkage between the poor diets, poor health, and high health care costs of Americans. The first step to recovery is changing the way food is grown, produced, and distributed in America.

Despite, but possibly due to, the negative healthcare trends, the average American consumer is becoming more educated about his/her food purchases and options. This increase in awareness and conscious choice to eat higher quality and more environmentally sustainably produced foods comes from a declining rate of food insecurity, increase in available alternative options with the rise of stores such as Whole Foods Market, and recent public inundation with news coverage, documentaries, and books revealing the horrors of how the natural food that Americans consume is manufactured.

Food insecurity in America has been consistently declining, as exhibited by the “statistically significant”³ 4.03 percent relative decline in the rate of “households [that] were food insecure at least some time during the year.”⁴ The world has been following this trend towards an improving food security and nourishment, or “hav[ing] dependable access to enough food for active, healthy living.”⁵ The Food and Agriculture Organization of the United Nations reported a 39.57 percent relative decline in worldwide food insecurity in 2014 such that “[b]etween 1990-92 and 2012-14, the

³ Alisha Coleman-Jensen, Christian Gregory, and Anita Singh, “Household Food Security in the United States in 2013, ERR-173,” U.S. Department of Agriculture, Economic Research Service, September 2014.

⁴ Coleman-Jensen, Gregory, and Singh, “Household Food Security in the United States.”

⁵ Coleman-Jensen, Gregory, and Singh, “Household Food Security in the United States.”

prevalence of undernourishment has fallen from 18.7 percent to 11.3 percent at the global level, and from 23.4 percent to 13.5 percent in developing countries.”⁶ Although food deserts, or “urban neighborhoods and rural towns without ready access to fresh, healthy, and affordable food,”⁷ still exist, it can be inferred from the data that a need for Americans to focus on sourcing their next meal is quickly declining, even in times of historically high unemployment and a poor national economy such as during the recession of 2007-2009.⁸

A steady decline in food insecurity correlates with a shift from Inglehart-Welzel’s “survival values [which] place emphasis on economic and physical security”⁹ towards “self-expression values [which] give high priority to environmental protection...and rising demands for participation in decision-making in economic and political life.”¹⁰ In the 2011 Wave 6 Survey results for the World Values Survey, only 2.7 percent of Americans responded that “in the last 12 months [they or their families had] gone without enough food to eat”¹¹ while 87.1 percent of survey takers responded positively as people who identified somewhat with the statement: “Looking after the

⁶ FAO, IFAD and WFP, “The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition,” Rome, FAO, 2014.

⁷ “Food Deserts,” United States Department of Agriculture, <http://apps.ams.usda.gov/fooddeserts/fooddeserts.aspx>, accessed April 18, 2015.

⁸ “BLS Spotlight on Statistics: The Recession of 2007-2009,” U.S. Bureau of Labor Statistics, http://www.bls.gov/spotlight/2012/recession/pdf/recession_bls_spotlight.pdf, accessed April 18, 2015.

⁹ “Findings and Insights,” World Values Survey, <http://www.worldvaluessurvey.org/WVSContents.jsp>, accessed April 18, 2015.

¹⁰ “Findings and Insights.”

¹¹ “World Values Survey Wave 6 2010-2014 Official Aggregate v.20150418,” World Values Survey Association (www.worldvaluessurvey.org), Aggregate File Producer: Asep/JDS, Madrid, Spain.

environment is important to this person; to care for nature and save life resources.”¹²

Americans focus less on finding food for survival, which lends itself to a values shift towards caring more about the environment. This shift in circumstance and values places more of an emphasis on moral and environmental responsibility and the correlation between economic success and the preservation of nature. With the removal of the intimate and intense focus on survival, Americans begin to question standards and authority and seek a larger, more intellectual, role in society to change the system for the better. Some changes seen in recent years have been the implementation of national health care changes with the Affordable Care Act (ACA) and support for the first lady’s efforts to improve school lunches and labeling on processed foods.

Although not the whole of America is comprised of these environmental and health conscious consumers, this shift has caught the attention of the manufacturers, politicians, farmers, and food markets. The most blatant example of catering to this shift occurs at Wal-Mart stores. Traditionally thought of as places for bargain shoppers, and usually filled with cheap and discounted processed foods, Wal-Mart Stores have been partnering with local, organic farms and companies from which to source its fresh foods. Part of this shift in sales of organic, local products can be attributed to the rising popularity of these types of items found at other bargain stores, such as Target, and to the growth of organic and local-focused stores like Whole Foods. However, the biggest contributing factors are cost and logistics. The increase in fossil fuel and shipping costs, both monetarily and as impacts on the environment, have led Wal-Mart to shift its strategy toward adopting more sustainable supply chain ahead of the curve.

¹² “World Values Survey Wave 6 2010-2014 Official Aggregate v.20150418.”

In as early as 2006, then Chief Executive Officer of Wal-Mart announced an “ambitious goal to transform Wal-Mart into a company that runs on 100 percent renewable energy and produces zero waste.”¹³ This goal contradicted operating procedures at the time, as Wal-Mart “ha[d] been charged with exacerbating suburban sprawl, burning massive quantities of oil via its 10,000-mile supply chain, producing mountains of packaging waste, polluting waterways with runoff from its construction sites, and encouraging gratuitous consumption.”¹⁴ Despite committing obvious harm to the environment, Wal-Mart’s supply chain and logistics strategies are studied, proliferated, and world-renowned. The changing American consumer may impact sales and profits, but Wal-Mart’s shift represents more than an attempt to recapture a demographic – it shows a change in the definition of efficiency and systemic costs.

Wal-Mart has shifted to purchasing fresh fruits and vegetables (FFV) and dairy products from local and organic farmers in many of its stores. From a straight cost of goods versus price sold standpoint, this shift negatively impacts profit margins on these items—which have small margins with which to begin. The overall cost of transporting and properly storing FFV and dairy products from across America, and accounting for a much higher percentage chance of waste due to spoilage which inherently increases buffer stock, outweighs the increase in cost of goods sold from moving to a local and/or organic supply of FFV and Dairy. This small supply chain change produces drastic effects, such as:

- Decreases in waste, from energy waste to waste due to spoilage

¹³ Amanda Little, “An interview with Wal-Mart CEO H. Lee Scott,” *Grist*, April 13, 2006, accessed April 23, 2015, <http://grist.org/business-technology/griscom-little3/>.

¹⁴ Little, “An interview with Wal-Mart CEO H. Lee Scott.”

- Decreases in safety stock cost
- Decreases in transportation cost, impact on the environment, fossil fuel cost, and refrigeration and storage cost
- Decrease in bullwhip effect due to smaller lots
- Increase in quality from shorter transport times – food is picked closer to ripeness
- The ability to replenish stock in shorter intervals with higher certainty from various sources
- Recapture of lost consumers to stores with more health and environmentally-conscious sourcing, such as Whole Foods or the Target organic brand, Archer Farms

These positive impacts on the bottom line for Wal-Mart can be seen in other aspects of the American food supply system. Wal-Mart “sells 18 percent of all the groceries bought in the United States—more than anyone else by a wide margin,”¹⁵ which gives it the power to affect change in more than grocery sales – it can impact how food is produced and manufactured as the purchaser of 18% of all the groceries *sold* in the United States.

Between the impact of Wal-Mart making lofty, environmentally-focused goals and shifting its food supply chain strategy to a more local and organic one, and the rise of the more informed and aware American consumer, food manufacturers will have to

¹⁵ Tom Philpott, “Is Walmart Really Going Organic and Local?” *Mother Jones*, March/April 2012, accessed April 23, 2015, <http://www.motherjones.com/environment/2012/03/walmart-groceries-organic-local-food-deserts>.

change practices or be left behind. The current system of food production in the United States will eventually collapse unto itself as reports of contaminated macaroni and cheese with metal,¹⁶ baby food with glass shards,¹⁷ chicken sausage containing plastic fragments,¹⁸ and pork products possibly contaminated with Staphylococcal Enterotoxins,¹⁹ all with recall measures in the millions and tons and some with production runs of nearly a full year, force stricter regulation or a change in practice to preserve profits. The implications of a meat processing plants' entire year's production of pork products being recalled and considered by the United States Department of Agriculture's Food Safety and Inspection Service to be a "Class I Recall [with] Health Risk: High"²⁰ are great; from drastic profit loss, unrecoverable costs from production, additional costs of repaying sick consumers, legal fees from liability lawsuits, loss of supply contracts, loss of reputation, loss of repeat business, and the impact of recalling tons of meat products on the environment in terms of transportation and fossil fuel expense and waste management to the cost of toxin containment and the cost of

¹⁶ Elahé Izadi, "Kraft recalls more than 6 million boxes of macaroni and cheese because they may contain metal," *Washington Post*, March 18, 2015, accessed April 23, 2015, <http://www.washingtonpost.com/news/to-your-health/wp/2015/03/17/kraft-recalls-242000-cases-of-macaroni-and-cheese-because-they-may-contain-metal/>.

¹⁷ Melanie Eversley, "Baby food recalled after glass found in jar," *USA Today*, April 16, 2015, accessed April 23, 2015, <http://www.usatoday.com/story/news/2015/04/16/beechnut-glass/25861257/>.

¹⁸ Samantha Bonar, "Trader Joe's and other chicken sausage recalled," *LA Times*, April 21, 2015, accessed April 23, 2015, <http://www.latimes.com/food/dailydish/la-dd-trader-joes-chicken-sausage-recalled-20150421-story.html>.

¹⁹ United States Department of Agriculture, "B & R Meat Processing Recalls Pork Products Due to Possible Processing Deviation and Staphylococcal Enterotoxin Contamination," April 18, 2015, accessed April 23, 2015, <http://www.fsis.usda.gov/wps/portal/fsis/topics/recalls-and-public-health-alerts/recall-case-archive/archive/2015/recall-064-2015-release>.

²⁰ USDA, "B & R Meat Processing Recalls Pork Products."

improving quality assurance at the plant to prevent future recalls. In a competitive, market-based economic landscape such as that of the United States, companies cannot afford to lose whole years of profits and repeat business due to recalls of tons of product. These extensive costs of production will eventually push production towards a cleaner, safer, and better system of food manufacturing that relies heavily on lean and agile manufacturing principles.

PROPOSAL

The current food production system in America, from fresh fruits and vegetables to dairy to meat to the heavily processed foods resulting from these components, needs to change. The system puts American public health at risk by being susceptible to terror attacks on the food supply and undetected foodborne illnesses, sustaining disproportionately discounted prices on unhealthy foods versus healthy foods, and producing low quality fresh foods. The environment and economy stand to suffer as well – as “the food system uses more fossil fuel than any other sector of the economy – 19 percent”²¹ and “the way we feed ourselves contributes more greenhouse gases to the atmosphere than anything else we do – as much as 37 percent, according to one study.”²² Not only are food products shipped long distances in refrigerated containers, modern farming of fresh fruits and vegetables, meats, and dairy rely heavily on fossil fuels throughout the production process, from tilling the soil to manufacturing

²¹ Michael Pollan, “Farmer in Chief,” *New York Times*, October 12, 2008, accessed on April 23, 2015, http://www.nytimes.com/2008/10/12/magazine/12policy-t.html?pagewanted=all&_r=0.

²² Pollan, “Farmer in Chief.”

genetically modified seeds, pesticides, and herbicides. Using these resources on food that ends up wasted is a clearly waste in and of itself, but the inefficient system additionally wastes natural resources during every step of production. The system is not only environmentally unsustainable, but it is also becoming economically unstable and illogical. The rising costs of transportation, infrastructure upkeep, health care, power plant construction to keep up with energy demand, and fossil fuel spill clean up are just a few examples of how the food production system is churning out food at lower and lower sticker prices, but at higher systemic costs to the consumer.

Several scholars and environmentalists propose that the solution to these problems is a reversion to pre-Nixon era food manufacturing – from gardens at home to small, local farmers producing different crops year-round and having grazing animals for slaughter and dairy on-site. The major flaw in this plan is that the modern American household has become used to quick, easy, heavily processed foods. There are usually two breadwinners with full-time jobs managing an average of two children. Furthermore, the current generation of young adults, Millennials, are buying less houses than their predecessors due to the poor job economy, rising student loan and credit card debt, and a minimalistic lifestyle,²³ and apartment-style city-living does not lend itself to managing or growing a garden of fresh produce.

Some aspects of these proposals make logistical and scientific sense, such as Michael Pollan's suggestions to rely on the sun for energy and shift from monoculture farms and Concentrated Animal Feeding Operations (CAFOs) to a diversified self-

²³ "Millennials not quite ready to start buying homes yet," *CNN Money*, February 6, 2015, accessed April 23, 2015, http://money.cnn.com/2015/02/06/real_estate/millennials-housing/.

sustaining ecosystem comprised of many crops and animals.²⁴ He argues that planting monocultures destroys farmland, and without grazing animals and their natural fertilizer, farmers need more chemical-based fertilizers and herbicides to achieve the same results as manure. The cows would be healthier too, according to Pollan, because instead of the unnatural diet of corn and grain that is fed to them whilst they stand stationary in their own filth in crowded CAFOs, they are free to roam and eat the grass and overgrown weeds as they naturally would. As echoed in the documentary, *King Corn*, grass-fed cows require less antibiotics and chemicals to keep them alive, and produce natural, reusable fertilizer to farmers, whereas grain and corn-fed cows are sicker and weaker, and their waste is heavily polluted with chemicals from antibiotics and disease that it is no longer beneficial for planting crops.²⁵ Pollan also points out that “yield isn’t everything”²⁶ as “Americans throw out 14 percent of the food they buy,”²⁷ so the amounts being produced are unnecessary and wasting valuable resources that could be used to make higher quality, healthier food. The process to produce the food Americans eat is highly inefficient and most easily comparable to a mass production manufacturing facility operating at full capacity. However, the shelf life of the products it produces is much shorter than that of a commonly mass-produced item, such as a car, and the demand is not best met via this model. The result is a lot of wasted natural resources, energy, money, time, and final product.

²⁴ Pollan, “Farmer in Chief.”

²⁵ Aaron Woolf, *King Corn: You Are What You Eat*, Documentary Film, released April 13, 2007.

²⁶ Pollan, “Farmer in Chief.”

²⁷ Pollan, “Farmer in Chief.”

Economists and environmentalists have been attempting to understand how to incentivize shifting consumers and businesses towards more sustainable practices such as energy efficiency and green products in an effort to save energy. In *Climate Capitalism: Capitalism in the Age of Climate Change*, L. Hunter Lovins and Boyd Cohen provide a plethora of examples of both energy companies and consumers becoming more profitable while adopting more sustainable practices. Lovins and Cohen point to several cases in which companies that wait for regulatory changes to take hold fall behind by “ceding ground, perhaps irrevocably, to those demonstrating visionary leadership, responsible action, and the ability to capture public goodwill and patronage.”²⁸ If food manufacturers and consumers at each level of the supply chain followed this successful model to reduce waste and save costs before regulation forces these changes to happen, both parties will greatly benefit economically, while reducing the impact food production and consumption has on the planet.

The proposals of some forward-thinking scholars, journalists, businessmen, and politicians noted above allude to applications of Lean and Agile Manufacturing into the food production system. Adopting principles of Lean and Agile Manufacturing in the food production system, from seed to crop to consumer’s dinner table, will reduce the impact it has on the environment by making better use of resources, improve America’s public health, and reduce food costs, taxes, infrastructure costs, and healthcare costs. Lean Manufacturing is “the relentless pursuit of eliminating waste across an extended

²⁸ Boyd Cohen and L. Hunter Lovins, *Climate Capitalism: Capitalism in the Age of Climate Change* (New York: Hill and Wang, 2011), 55-56.

supply chain,”²⁹ and waste costs the economy and the environment the most in America’s present food production system. Proponents of Lean, such as Toyota and United Technologies Corporation, use different techniques in manufacturing associated with this way of thinking in order to reduce waste in their production cycles and ultimately make a higher quality product for less. These techniques, such as just-in-time manufacturing, reduction in non-value added work, low inventory and safety stock, and closed loop systems that reuse resources, are designed to invest more up front to reduce the cost of poor quality and mistakes leading to recalls, waste, and unhappy customers.

THE CURRENT SYSTEM VS. THE PROPOSED SYSTEM

Lean Manufacturing has been essential in increasing agility. Agility suggests that

Like profitability, organizational adaptability is a core viability requirement. To continue as a viable entity, an organization must meet two conditions: (1) It must generate at least as much fuel as it consumes (profitability) and (2) It must continuously adapt as necessary to changing environmental conditions.³⁰

Food manufacturing as it exists in America today has not adapted enough to be considered Agile or Lean. The system still largely resembles a mass production line of the past without adjustments for present resource limitations and changing demands.

The following key aspects of Lean and Agile Manufacturing when applied to food production will reduce the overall cost of the system:

²⁹ Robert J. Trent, *End-to-End Lean Management: A Guide to Complete Supply Chain Improvement* (Fort Lauderdale: J. Ross Publishing, 2008), 5.

³⁰ Rick Dove, *Response Ability: The Language, Structure, and Culture of the Agile Enterprise* (New York: John Wiley & Sons, 2001), 3.

1. Agility: “The ability to manage and apply knowledge effectively”³¹
 - a. Knowledge about the weaknesses in America’s food production system has been public for nearly 20 years. At the very least, politicians and food manufacturers have had high-level, if not detailed, access to studies showing that the system is outdated and adversely affecting America. According to a report prepared by a partnership of the Food and Drug Administration, United States Department of Agriculture, United States Environmental Protection Agency, and Centers for Disease Control and Prevention in May 1997, or nearly 18 years before the four food recalls mentioned in the introduction, “The system for identifying and preventing foodborne illnesses...was largely created in the early 1900s... The System cannot properly identify, track, and control food-related illness, or prevent, to the extent possible, future cases from occurring.”³² Since the 1997 report, the “FDA’s Center for Food Safety and Applied Nutrition (CFSAN) announced...a single adverse event reporting system”³³ in 2002 that consolidated three different reporting systems and planned to “improve the monitoring and analysis of adverse events

³¹ Dove, *Response Ability*, 15.

³² Food and Drug Administration, U.S. Department of Agriculture, U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, “Food Safety From Farm to Table: A National Food Safety Initiative, Report to the President,” May 1997, Accessed April 23, 2015, <http://www.cdc.gov/ncidod/foodsafety/report.htm#prepared>.

³³ Robert Ross, “FDA planning new adverse-event reporting system for food, supplements,” University of Minnesota Center for Infectious Disease Research and Policy, September 13, 2002, accessed April 23, 2015, <http://www.cidrap.umn.edu/news-perspective/2002/09/fda-planning-new-adverse-event-reporting-system-food-supplements>.

related to food products.”³⁴ This centralized system came about largely as a response to the terror attacks on the United States on September 11, 2001, which also led to the enactment of the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, which aims to prevent domestic food supply contamination from foreign nations as a security precaution. In 2006, the FDA required “that food labels would have to include the amount of *trans* fat content”³⁵ and in recent years, the first lady, Michelle Obama, has worked to improve school lunches and nutritional labeling.

- b. However, as explained in detail in the documentary *Fed Up*, Michelle Obama’s efforts to improve America’s children’s health have been largely curbed by lobbyists and food regulators in Washington, DC.³⁶ Despite public reports by federal agencies, such as the Centers for Disease Control and Prevention, that Americans of all ages are fighting a losing battle against heart disease, diabetes, and obesity – all of which are conditions caused by and can be abated by diet – lobbyists and regulators have not done anything to change the food production system or greatly enhance consumer protection since before the Clinton Administration’s report. The small changes noted above made between

³⁴ Ross, “FDA Planning new adverse-event reporting system for food.”

³⁵ Michelle Meadows, “A Century of Ensuring Safe Foods and Cosmetics,” *FDA Consumer Magazine*, January-February 2006, accessed April 23, 2015, <http://www.fda.gov/AboutFDA/WhatWeDo/History/FOrgsHistory/CFSAN/ucm083863.htm>.

³⁶ March Monroe and Stephanie Soechtig, *Fed Up*, Documentary Film, released January 19, 2014.

1997 and present do not proportionately reflect the changes needed in the system to prevent destruction and extinction.

c. The impacts of impending energy shortages, saturating land with chemicals from pesticides, herbicides, and antibiotics, feeding animals unnatural diets of corn and antibiotics, and planting monoculture crops have been known for at least six and one-half years since Michael Pollan noted them in a published open letter to the President. The only suggestion notably taken from Pollan's open letter was the planting of an organic garden in the South Lawn. This knowledge cannot wait years to be employed and go ignored as the associated risks and costs are too great. Reports by international organizations, such as one 2011 report by the Food and Agriculture Organization of the United Nations and the International Dairy Federation,³⁷ have "encourage[d]...farmers to adopt 'proactive' preventative practices rather than waiting for problems to occur"³⁸ and warned that "implementing good...farming practice is good risk management for the short and long term future of...farming enterprise[s]."³⁹

³⁷ Food and Agriculture Organization of the United Nations and International Dairy Federation, "Guide to good dairy farming practice," *FAO Animal Production and Health - Guidelines* 8, Rome 2011, accessed on April 25, 2015, <http://www.fao.org/docrep/014/ba0027e/ba0027e00.pdf>.

³⁸ FAO, IDF, "Guide to good dairy farming practices," 1.

³⁹ FAO, IDF, "Guide to good dairy farming practices," 1.

d. These practices are recommended and not required, and as “knowledge that cannot be applied has no value,”⁴⁰ these reports of our food production systems’ unsustainable weaknesses, and recommendations of what needs to happen to remedy them, are useless. Knowledge systems and communication measures need to be adopted beyond recognizing best practices and potential flaws in the system. Farms, businesses, consumers, and regulatory agencies need to communicate effectively and efficiently in order to produce crops that maintain biodiversity, feed all Americans fairly and healthily, prolong the availability of natural resources, and keep the food supply safe from harmful diseases and terror attacks.

2. Agility requires “organizing for change and complexity.”⁴¹

- a. America is not organizing for complexity – the “United States is, by far, the largest producer of corn in the world, producing 32 percent of the world’s corn crop in the early 2010s. Corn is grown on over 400,000 U.S. Farms”⁴² spanning “84 million acres [of] harvested area.”⁴³ In 2013, this number grew to “97 million acres – an area roughly the size of

⁴⁰ Dove, *Response Ability*, 14.

⁴¹ Dove, *Response Ability*, 16.

⁴² United States Environmental Protection Agency, “Major Crops Grown in the United States,” accessed on April 25, 2015, <http://www.epa.gov/agriculture/ag101/cropmajor.html>.

⁴³ US EPA, “Major Crops.”

California”⁴⁴ as “corn uses more land than any other crop.”⁴⁵ Producing the most of one crop is quite simple, and negatively impacts biodiversity that agriculture and ecological systems need to be sustainable. Most of the corn produced is exported, processed into corn syrup for highly processed and unhealthy foods, like candies and sodas, processed into feed for livestock, or processed into ethanol to fuel cars. Including foods containing processed corn, such as high fructose corn syrup, “about 12% of the U.S. corn crop ends up in foods.”⁴⁶ In 2013, America wasted more farmland to produce corn *not* consumed as food than it used to produce corn for all purposes two years prior – 88% of 97 million acres, or 85.35 million acres.

- b. America’s food system feeds and accommodates a wide range of tastes, species, cultures, preferences, and needs. More importantly, the environment requires that it should not and cannot be one-size fits all, as “[b]iodiversity is an important part of ecological services that make life livable on Earth...include[ing] everything from cleaning water and absorbing chemicals...to providing oxygen for us to breathe.”⁴⁷ Furthermore, “[m]aintenance of this biodiversity is essential for the

⁴⁴ Jonathan Foley, “It’s Time to Rethink America’s Corn System,” *Scientific American*, March 5, 2013, accessed on April 25, 2015,

<http://www.scientificamerican.com/article/time-to-rethink-corn/>.

⁴⁵ Foley, “It’s Time to Rethink America’s Corn System.”

⁴⁶ US EPA, “Major Crops.”

⁴⁷ National Wildlife Federation, “What is Biodiversity?” accessed April 25, 2015, <http://www.nwf.org/Wildlife/Wildlife-Conservation/Biodiversity.aspx>.

sustainable production of food and agricultural products”⁴⁸ as “[f]or crops and domestic animals, diversity within species is at least as important as diversity between species.”⁴⁹

- c. Although American consumers waste food from buying more than they consume, and the farms produce more than necessary, part of that production excess is due to using most of the farmland for corn, soy, and wheat crops⁵⁰ – all of which are then heavily processed to make sugary carbohydrates with longer shelf lives. Eventually, these millions of acres of monoculture crops, untouched by animals and saturated with chemicals from genetically modified seed (which is classified as a pesticide⁵¹), will run out of natural resources and production capacity from lack of biodiversity. Reorganizing American farmland to produce different crops based on the changing seasons will better use natural resources while improving biodiversity, preserving the environment needed to produce food and sustain domestic animals, and reduce waste as it reshapes the American diet according to laws of supply and demand.

3. Lean Manufacturing reduces inventories by focusing on just-in-time delivery and demand management.

⁴⁸ Convention on Biological Diversity, “Why is it important?” accessed April 25, 2015, <https://www.cbd.int/agro/importance.shtml>.

⁴⁹ Convention on Biological Diversity, “Why is it important?”

⁵⁰ US EPA, “Major Crops.”

⁵¹ Woolf, *King Corn*.

- a. Although parts of America, and the world, do not get enough food to eat and have trouble sourcing meals, America wastes billions of dollars in food each year. This waste is largely due to overproduction and poor inventory management. Despite difficulties measuring or accounting for nature – hence guides like the *Farmer's Almanac* for predicting weather and crop yields – when several types of foods are grown across the country rather than in a concentrated monoculture crop, the probability of having a successful yield goes up. The subsidy structure that was designed to protect farmers from poor seasons and keep them growing in coming years has become convoluted and twisted in ways that only help big agriculture and large yields of corn, soy, and wheat.
- b. America needs to reorganize, as “the future of organizational structures is based on small, interacting, self-organizing, autonomous units, sharing a common framework that facilitates reconfiguration and adaptation,”⁵² and divide up giant acreages of farmland used entirely for corn into smaller farms used to produce food consumed as natural foods. Reorganizing to adopt lean manufacturing practices would involve reconfiguring demand to produce the fresh fruits, vegetables, meats, and dairy products that local populations require and lack, rather than producing one large crop that is shipped internationally. Implementing just-in-time delivery alongside this reorganization would ensure that people are eating foods while ripened rather than before reaching full

⁵² Dove, *Response Ability*, 17.

maturity or spoiled. Reduction in yield expectations according to reduction in refrigerated inventory spaces and more regular consumption of fresh foods will reduce the impact food storage has on the environment, as well as bring down costs and waste of overproduction of unconsumed food.

4. Lean manufacturing focuses on cutting down on wasteful mistakes and poor quality.
 - a. As noted in the introduction, American food supplies continue to be contaminated at an alarming rate. Inspectors cannot keep up with the amount of production and the centralized system of processing food put in place to address this issue is outdated and ineffective. Centralized food processing makes tracking and measurement nearly impossible, and measures taken by the FDA after the September 11, 2001 attacks are not enough to abate the frequent contamination of meats with diseases, processed foods with shards of metal, and vegetables with harmful chemicals.
 - b. Lean proposes that implementing intense quality assurance measures throughout every step of production and clear, concise reporting methods and metrics for improvement capture these wasteful quality problems early enough to prevent large systemic costs. For example, recalls for meat products would be found immediately and impact lower lot sizes – versus the recall of chicken sausage mentioned in the introduction, which impacted a production run of nearly one-year. Given the shelf life of the

chicken sausage itself, the recall in April could only impact future consumers and a small percentage of recent consumers, which is ineffective, unsafe, and unhealthy. The cost of such a recall, if health problems are linked to the sausage and American consumers follow up with the company, could put the company out of business. Lean manufacturing quality assurance methods ensure that problems such as this never lead to bankruptcy by measuring everything, often.

5. Lean manufacturing reduces waste by reusing energy or space in a productive manner.
 - a. American farms are becoming more and more centralized and specific – producing monocultures of corn or only managing chickens – rather than diversified. This system means that farmers of corn need to buy fertilizer and chemicals to protect plants from weeds and insects or bring in swarms of bees to pollenate almond crops in California rather than relying on the naturally occurring amount of bees for pollination.⁵³ This lack of effective resource utilization resembles old silo-ed manufacturing practices that created poor products and ultimately led to American auto manufacturers' bankruptcy.⁵⁴

⁵³ Tom Philpott, "Are Your Delicious, Healthy Almonds Killing Bees?" *Mother Jones*, April 29, 2014, accessed April 25, 2015, <http://www.motherjones.com/tom-philpott/2014/04/california-almond-farms-blamed-honeybee-die>.

⁵⁴ Ross Eisenbrey, "Management – bad management - crippled the auto industry's Big Three, not the UAW," *Working Economics*, Economics Policy Institute, May 24, 2012, accessed April 25, 2015, <http://www.epi.org/blog/bad-management-crippled-auto-industry-big-three/>.

- b. If farmers planted diverse crops and managed a variety of grass-fed domesticated animals, they would be supplied with environmentally sustainable fertilizer and need less herbicides and pesticides. The ecosystem of each farm would be balanced and more effectively using natural resources as a full product lifecycle. The reduction of chemicals and antibiotics in meat and produce would allow for composting and safe decomposition of these products to act as fertilizers in and of themselves. Improved biodiversity would generate higher, healthier yields of crops in demand, and feed local populations at a lower cost.

RESEARCH DESIGN AND LIMITS OF THIS STUDY

Due to legal restrictions and data protections, gathering data to prove this thesis was not feasible. The government does not release, and potentially does not track, enough data to prove that the system is highly inefficient. Extensive studies have been done on whatever aspects of food production are clearly illogical and unhealthy, and they have been cited here. When examining the system as a whole, it can be logically deduced that the system is unsustainable from health, economic, and environmental standpoints. The implications of doing nothing are discussed below.

The only way to test this thesis would be to adopt lean manufacturing and agility in a region and monitor the effects. Several other studies propose similar methods to achieving the same results, and have come to the same conclusion, such as a plan

proposed by MIT aiming to reduce childhood obesity rates.⁵⁵ The unfortunate nature of great systemic change is that it is not easily tested. However, the rise of the educated consumer, changes in healthcare policies, diet being a large part of the health care debate, and documentaries made by major news stations with high research budgets, such as *Fed Up*, provide hope that the data needed to prove this system works will eventually become available or accessible. The relationship between the current food production system and former failed manufacturing systems, and those similar systems compared to those that adapted through Lean and Agile and survived systemic changes, also provides support for the logic set forth in this thesis.

HEALTH IMPLICATIONS

Using Lean and Agile manufacturing techniques, food production must be decentralized, diversified, and *more natural*. Animals must be fed logically natural diets – America must stop producing corn to feed domesticated animals, including fish. As noted in *King Corn*, corn is not the natural diet for animals with hooves that cannot remove husks from or pick the plant.⁵⁶ By that logic, and the scientific fact that corn does not grow in the ocean or freshwater ecosystems within which fish live, American fish farmers must stop feeding corn diets to fish as well. These unhealthy and unnatural diets cause the domesticated animals to develop new, adapting diseases regularly that can hardly be abated by regiments of antibiotics. Furthermore, the antibiotics and

⁵⁵ MIT Collaborative Initiatives, “Projects: Childhood Obesity,” accessed on April 25, 2015, <http://collaborative.mit.edu/projects/childhood-obesity>.

⁵⁶ Woolf, *King Corn*.

diseases the animals develop end up in the food products into which the animals turn, as do the pesticides sprayed on American crops. American consumption of these chemicals and drugs has been proven to negatively impact human health.⁵⁷

Corn Feed → Disease → Antibiotics → Reduction in Human Capacity to Fight Disease

One of the easiest ways to tackle the American health problem is to reduce production of corn and repurpose the nearly 100 million acres used to produce corn to produce natural, healthy food. Corn production allows for cheap processing of the sugar substitute – high fructose corn syrup. As examined in *Fed Up*, nutrition policy suggested cutting fat from diets to combat heart disease. In order to produce cheap food that tasted good without fat, food giants such as Kraft and Kellogg, began replacing fat with sugary-tasting high fructose corn syrup. Since this shift in policy in the 1970s-1980s, the rates of heart disease, obesity, and diabetes have only gone up and are adversely affecting children and socio-economically disadvantaged populations disproportionately.⁵⁸ Replacing corn acreage with fresh fruits and vegetables and grazing grounds for grass-fed domestic animals, would shift the availability and cost of high fructose corn syrup. Businesses would have to use natural ingredients or abandon current processing practices that are harmful for consumers, and consumers would have

⁵⁷ Stuart B. Levy, “Factors impacting on the problem of antibiotic resistance,” *Journal of Antimicrobial Chemotherapy*, 49 (2002): 25-30, accessed April 25, 2015, doi: 10.1093/jac/49.1.25.

⁵⁸ Monroe and Soechtig, *Fed Up*.

to revert back to the more natural, healthy diets they had before the rise of processed, sugary carbs.

Cheap Corn → Cheap High Fructose Corn Syrup → Cheap Processed, Unhealthy Foods
→ Disproportionately Unhealthy Poor Populations

With the shift in diet towards natural, balanced meals, Americans will have more energy, lose weight, and get sick less. Science has gone so far as to prove that organic crops are more nutritious than conventionally produced crops,⁵⁹ and with a lean-defined yield tied more acutely to a demand of a variety of FFV, producing crops organically becomes more affordable.

ENVIRONMENTAL IMPLICATIONS

Although proponents of ethanol claim that production of corn cheapens the cost of gas and reliance on fossil fuel for transportation, the amount of fossil fuel used to produce the corn replacing the fossil fuel is more than the yield of ethanol.⁶⁰ The natural resources used to produce crops will no longer be going to waste and more efficiently monitored. Reducing production to satisfy a healthier demand will reduce wasted resources on wasted foods. As “[s]ustainable development from a business

⁵⁹ Kirsten Brandt and Jens Peter Molgaard, “Organic agriculture: does it enhance or reduce the nutritional value of plant foods?” *Journal of the Science of Food and Agriculture*, 81 (2001): 924-931, accessed April 8, 2015, doi: 10.1002/jsfa.903.

⁶⁰ Timothy A. Wise, “Running on Empty: U.S. ethanol policies set to reach their illogical conclusion,” *Global Development and Environment Institute of Tufts University*, July 23, 2012, accessed on April 25, 2015, <http://www.ase.tufts.edu/gdae/Pubs/rp/GC49July12Wise.pdf>.

perspective is defined as ‘meeting the needs of the business without compromising the ability of future generations to meet their own needs’,”⁶¹ businesses will realize that current use of natural resources is not sustainable for the future of the business and will learn to compromise on cost now in order to survive later. Wal-Mart’s shift in supply chain management as discussed in the introduction is an excellent example of a large giant sacrificing slightly higher costs now to invest in a sustainable supply chain for the future.

ECONOMIC IMPLICATIONS

The cost of food waste in America substantially outweighs the cost of producing less, more diverse, crops – as producing less saves money as well. In one year, America wastes “about 60 metric tons of food...with an estimated value of \$162 billion.”⁶² A farmer looking to produce higher quality crops in lower yields would have to sell the crops at a slightly higher price in order to regain the money spent on organic, natural foods. However, the farmer, food supplier, and restaurant should be able to charge more if Americans consume less. Adjusting demand to reduce waste would end up cheaper for all levels of the supply chain.

The costs do not end with the price paid to produce the tomato or its sticker price at the grocery store. Wasting food is very expensive; from the costs of waste

⁶¹ J. N. Sellahewa and W. Martindale, “The impact of food processing on the sustainability of the food supply chain,” *Aspects of Applied Biology*, 102 (2010): 91.

⁶² Ron Nixon, “Food Waste Is Becoming Serious Economic and Environmental Issue, Report Says,” *New York Times*, February 25, 2014, accessed April 25, 2015, http://www.nytimes.com/2015/02/26/us/food-waste-is-becoming-serious-economic-and-environmental-issue-report-says.html?_r=0.

management to the energy to store food that is never consumed to the energy that went into purchasing and transporting the food that is never consumed to the energy that goes into cooking food that is spoiled to the labor costs of all of the above, wasting food is bad for the economy. Paying slightly higher prices for less at the front end, but not wasting as much, is cheaper for the system as a whole.

CONCLUSION

The food production system must be changed in order to remain economically viable and environmentally sustainable. In its present state, it will bankrupt the government from requiring so much support or will end up in disrepair like much of former American auto-manufacturing. Food production in the United States is a far-reaching issue involving labor, infrastructure, national security, public health, and environmental protection, and the glaring issues in how Americans are supplied food need to be remedied before catastrophic consequences result.

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